

Space Debris Ranging Data Orbit Determination

**LIANG Zhipeng*, LIU Chengzhi,
FAN Cunbo, HAN Xingwei**

Changchun Observatory, National Observatories,
Chinese Academy of Sciences

contact: liangzp@cho.ac.cn

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Outline

In this presentation we:

- Analyze Changchun SDLRS data stats
 - Propose the method to fit orbit on single station/pass data
 - Test accuracy of fitted debris orbits
 - Find some use of it 😊
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Part I

System & Data



Changchun SDLRS

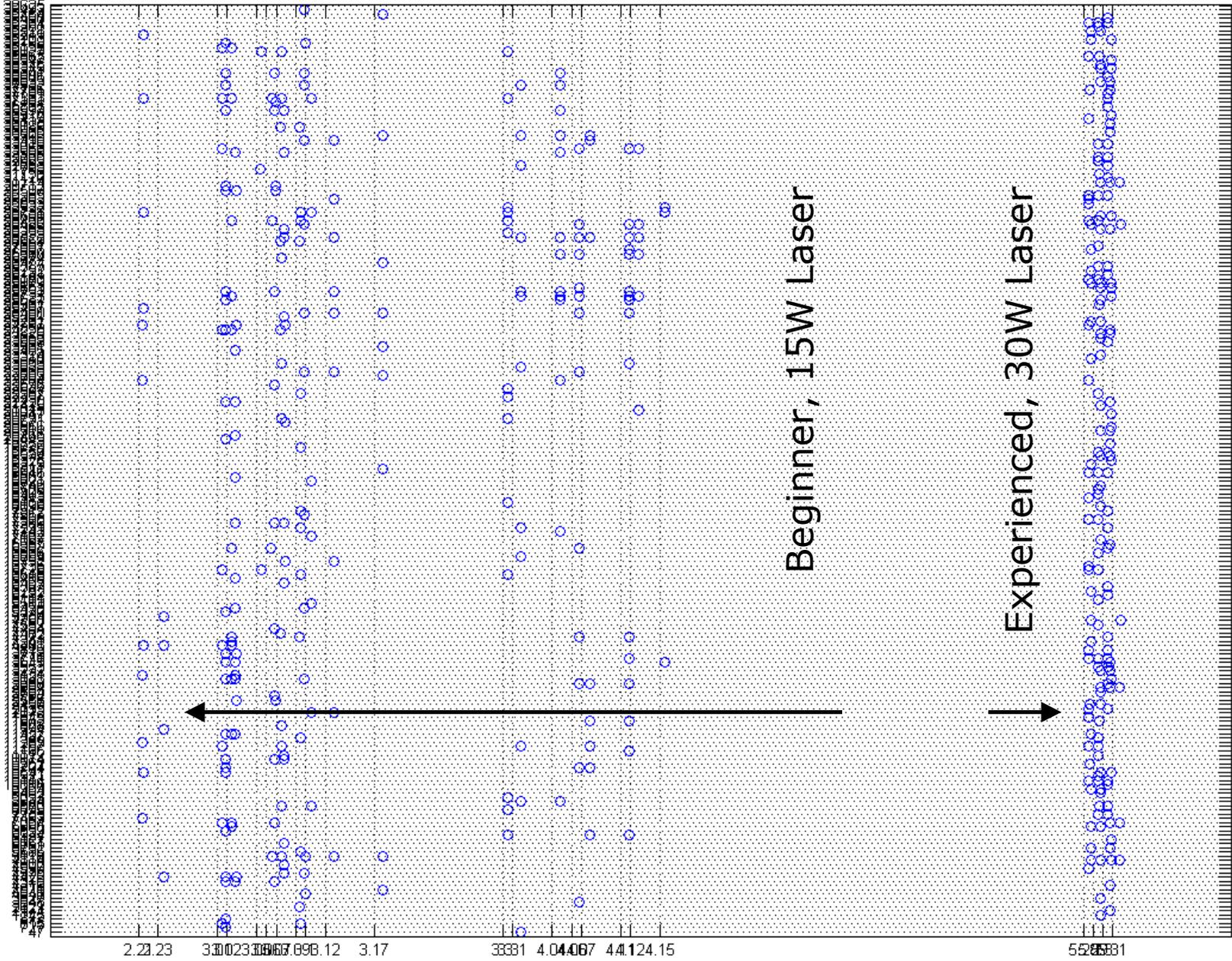
Space Debris Laser Ranging System

- ❑ Pulse Energy: 60mJ @532nm
- ❑ Repetition Rate: 1-500Hz
- ❑ Pulse Width: 9-10 ns
- ❑ Beam Divergence: 0.4 mrad
- ❑ $M^2 \leq 1.5$



Data Passes Date Distribution

Object NORAD IDs



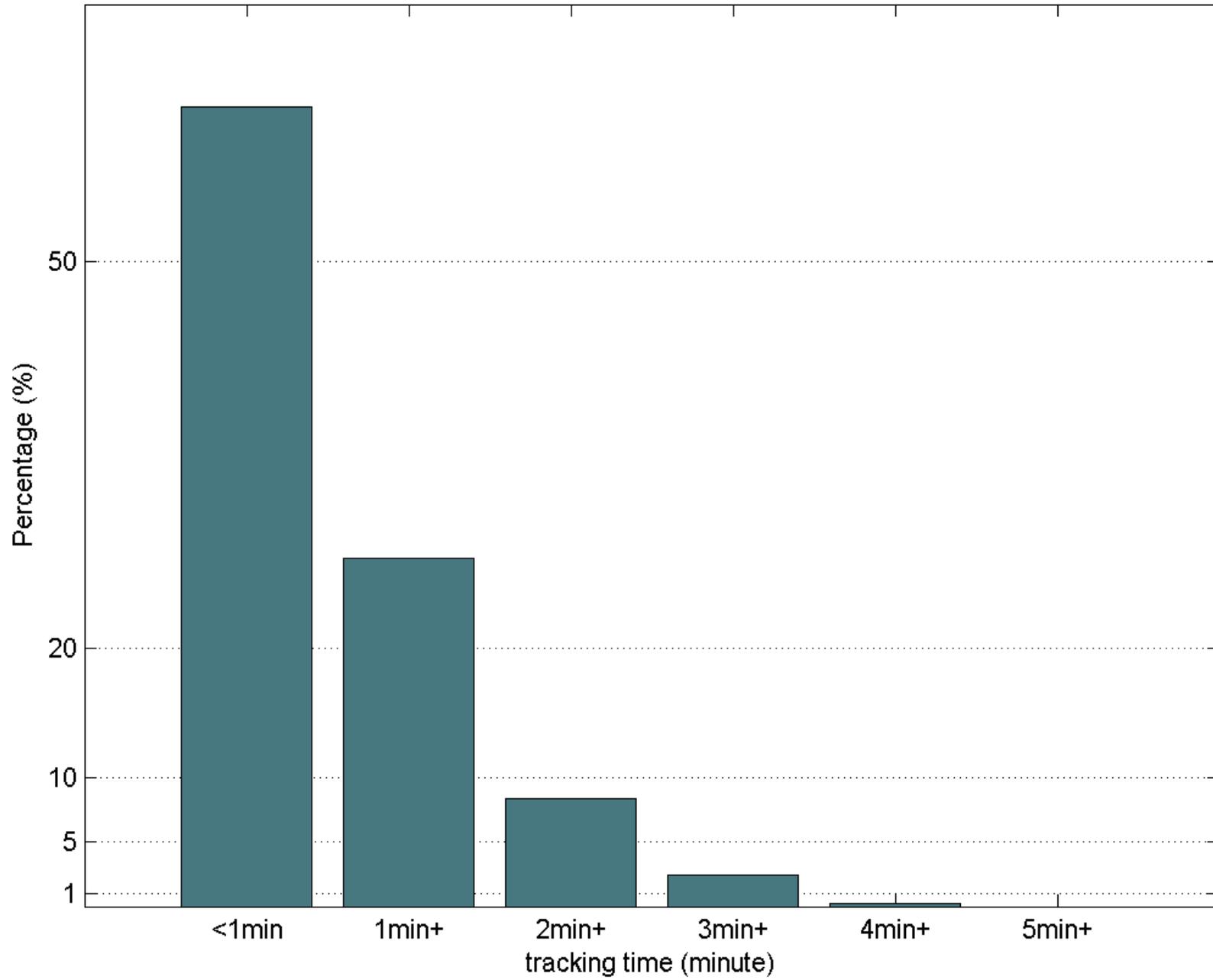
Calendar Date

Changchun SDLRS Data Stats

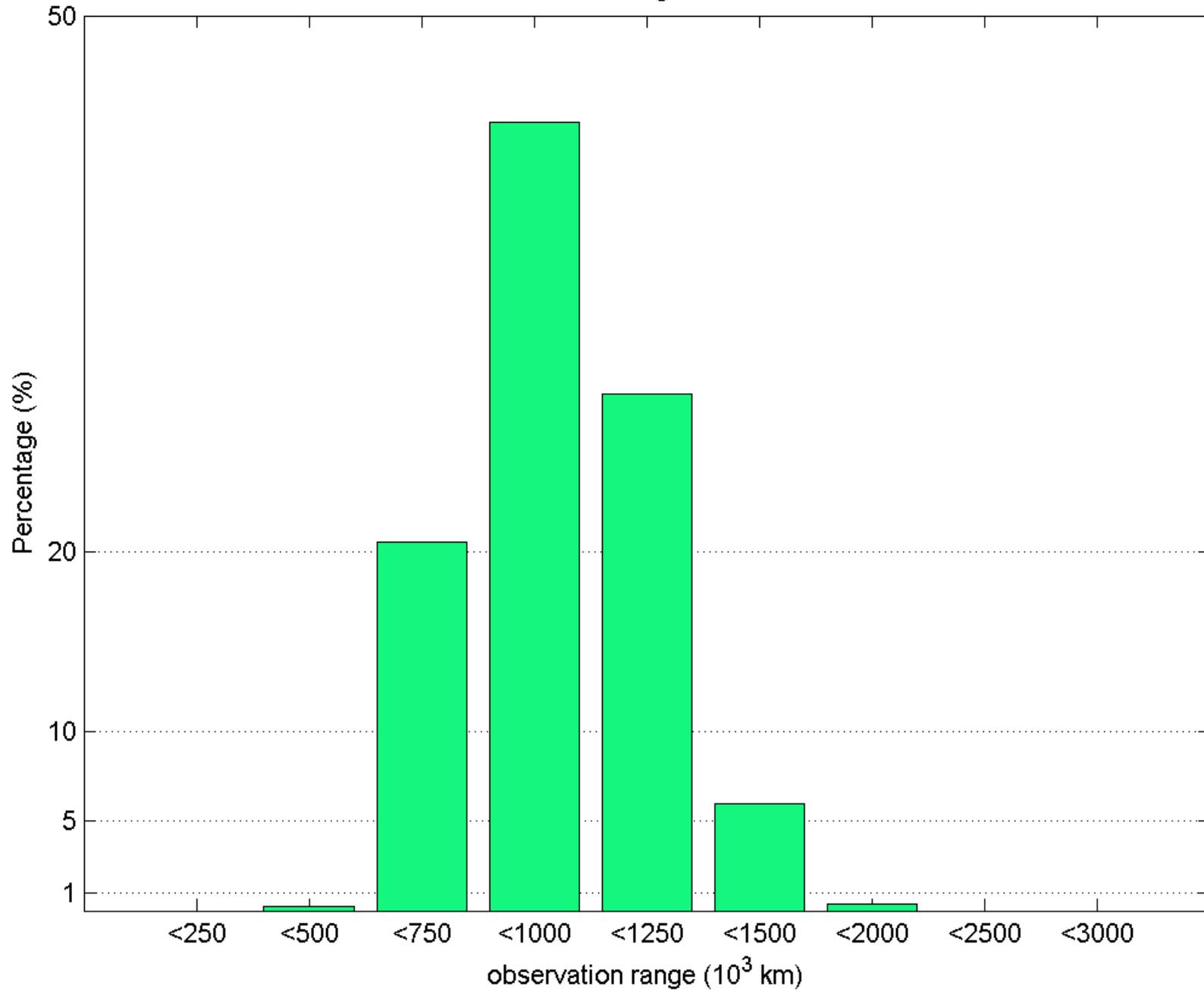
During Feb ~ May 2014:

- ❑ 466 passes / 233 space debris
 - ❑ 4890 NPTs / 412882 pts
 - ❑ 1.5m single shot precision
 - ❑ Data duration avg. 1.0 min
 - ❑ Measured range avg. 10^3 km
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observation length distribution



observation range distribution



Part II

Orbit & Assessment

Questions To Ask

- Is it possible for single station range data to improve space debris orbit accuracy?(w.r.t TLE)
 - Would other stations benefit from this improvement?
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Method of OD

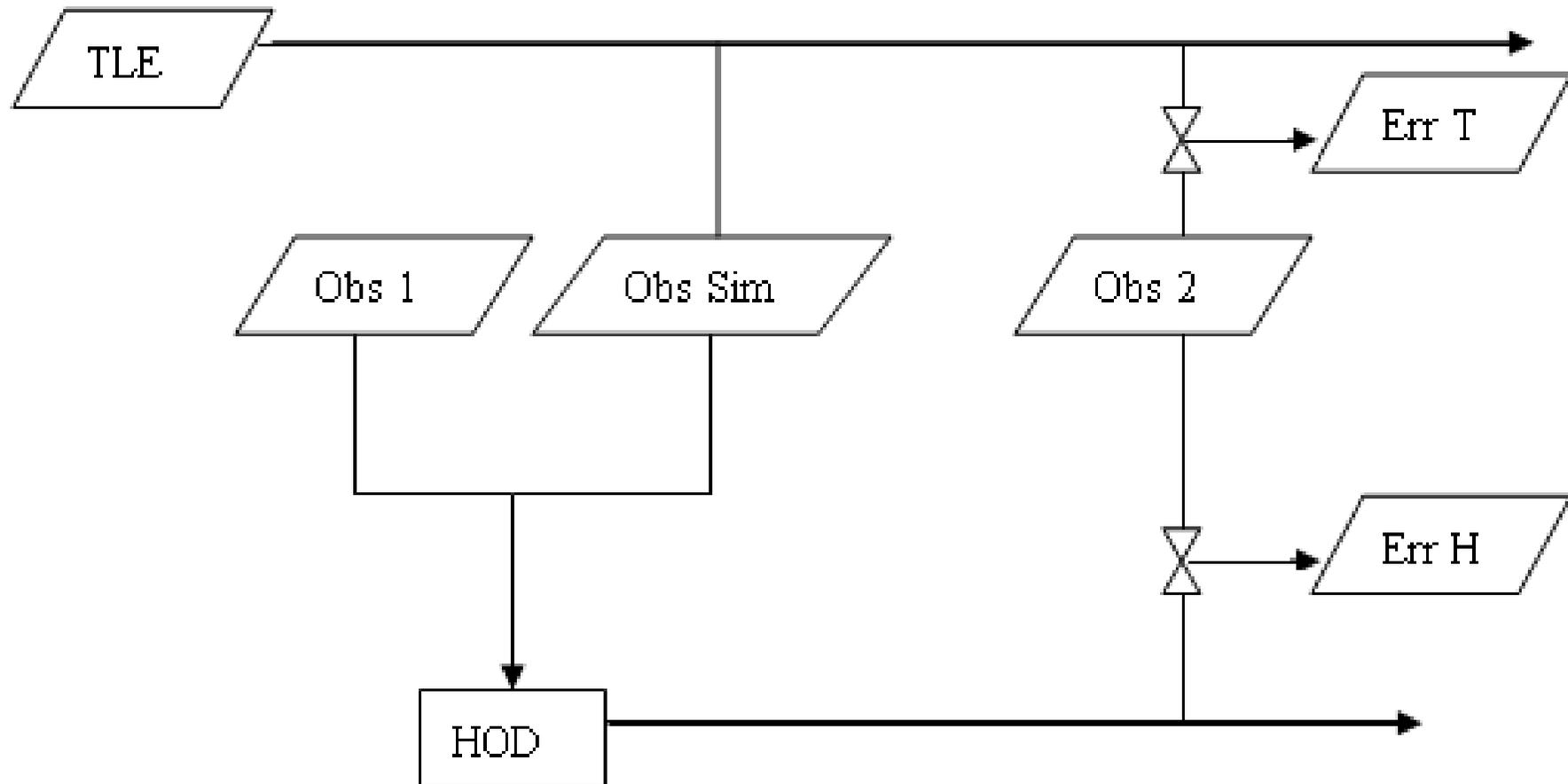
- Hybrid Orbit Determination(*)
 - Step 1: Use TLE as initial orbit
 - Step 2: Simulate network data by TLE
 - Step 3: Assign weight to real data and simulated data
- OD on mixture of real and sim data, thus named 'Hybrid'
- Real data is from single station/pass

(*) LIANG Zhi-peng, LIU Cheng-zhi, FAN Cun-bo, SUN Ming-guo, TLE-Aided Orbit Determination Using Single-station SLR Data, Chinese Astronomy and Astrophysics 36 (2012) pp. 417-425

Method of Assessment

- Step 0: Get TLE orbit for tracking
 - Step 1: Get two passes of obs.
 - Step 2: HOD fit on first pass
 - Step 3: Compare second pass with:
 - TLE prediction (producing Err T)
 - HOD prediction (producing Err H)
 - IF $ErrH < ErrT$, orbit is improved
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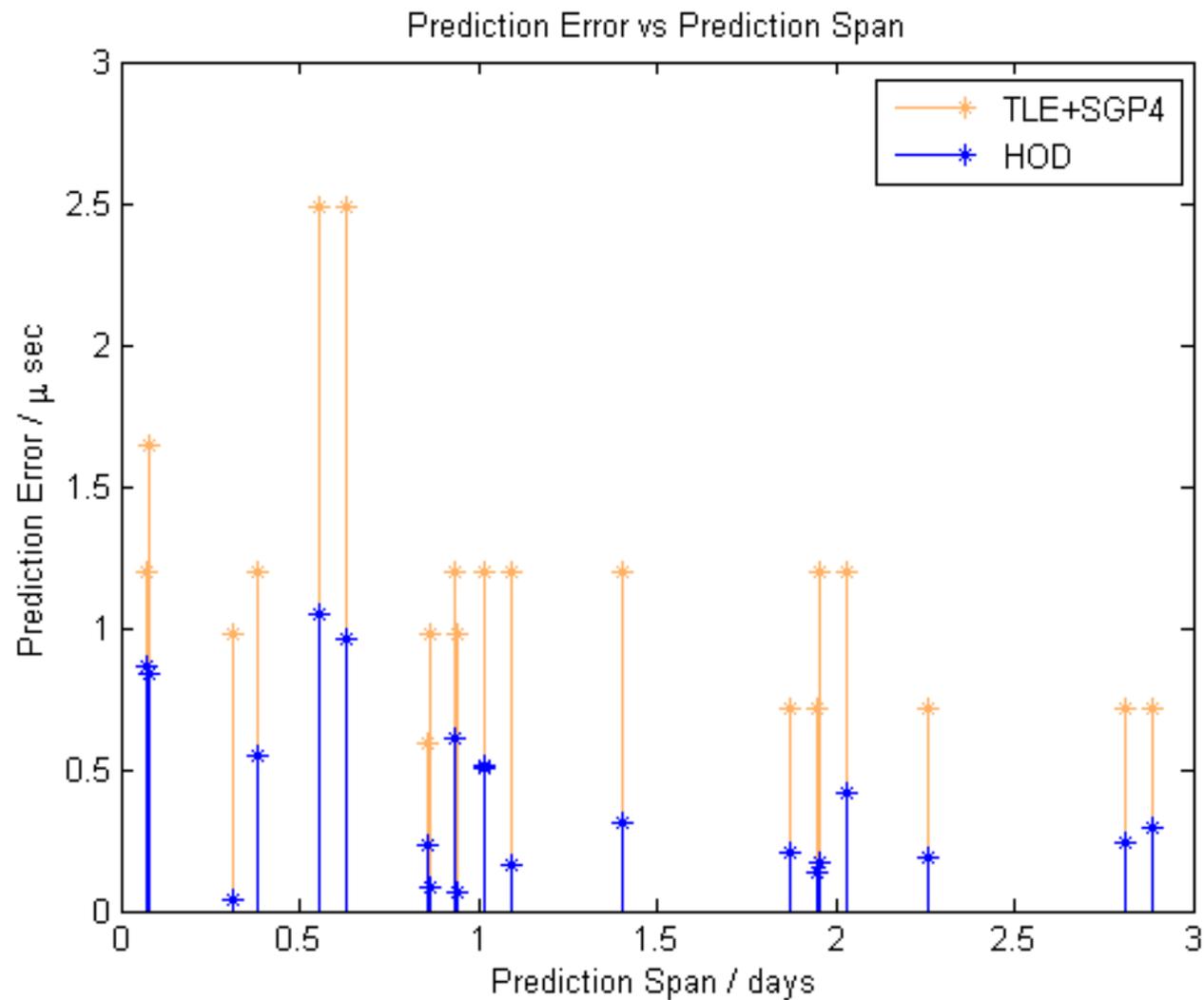
Method Flow Chart



Demo with Starlette data

- 7 passes in 3 days of starlette(07646)
 - HOD fit on every single pass
 - Compare passes with predictions (21 pairs)
 - Plotted with axes:
 - X – prediction span from fit pass to test pass, in days
 - Y – prediction error RMS in microseconds
 - Result: GOOD, $ErrH < ErrT$ for ALL
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Starlette Demo: Plot



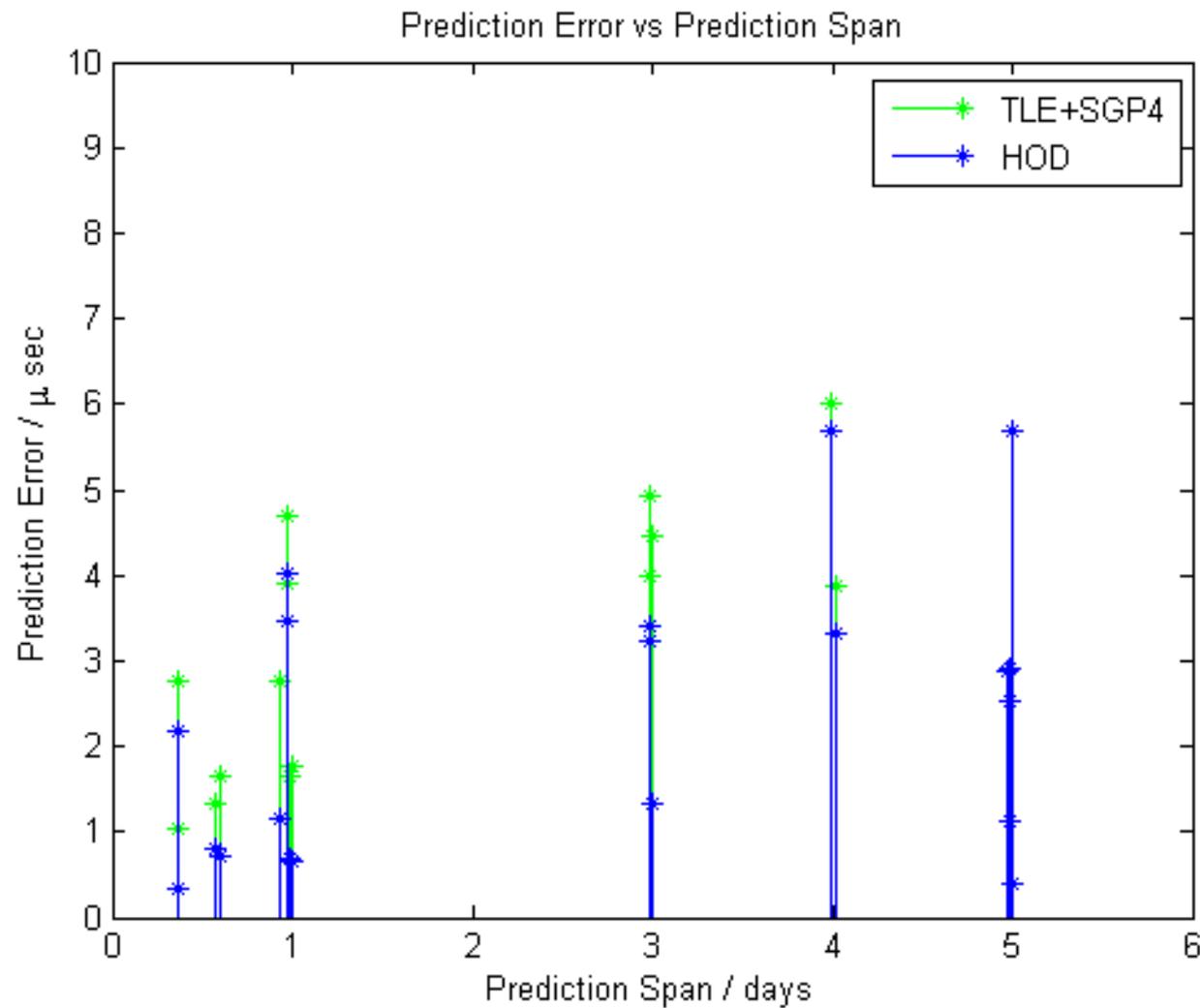
Space Debris Results

- ❑ Only >5 passes objects selected
 - ❑ Total 77 passes of 13 space debris
 - ❑ HOD fit on every single pass
 - ❑ 48 pairs with <5days gap
 - ❑ Result: 26/48 GOOD
 - ❑ Bad results may be due to incorrect object modeling
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Space Debris Results: Table

NORAD #	Comparations	ErrH < ErrT	Comment
11267	1	1	GOOD
13028	4	4	GOOD
14373	1	1	GOOD
24298	4	4	GOOD
25400	3	3	GOOD
25732	2	2	GOOD
28480	3	3	GOOD
28499	3	3	GOOD
05118	6	3	BAD
25723	4	0	BAD
28222	9	0	BAD
28738	1	0	BAD
37363	7	2	BAD

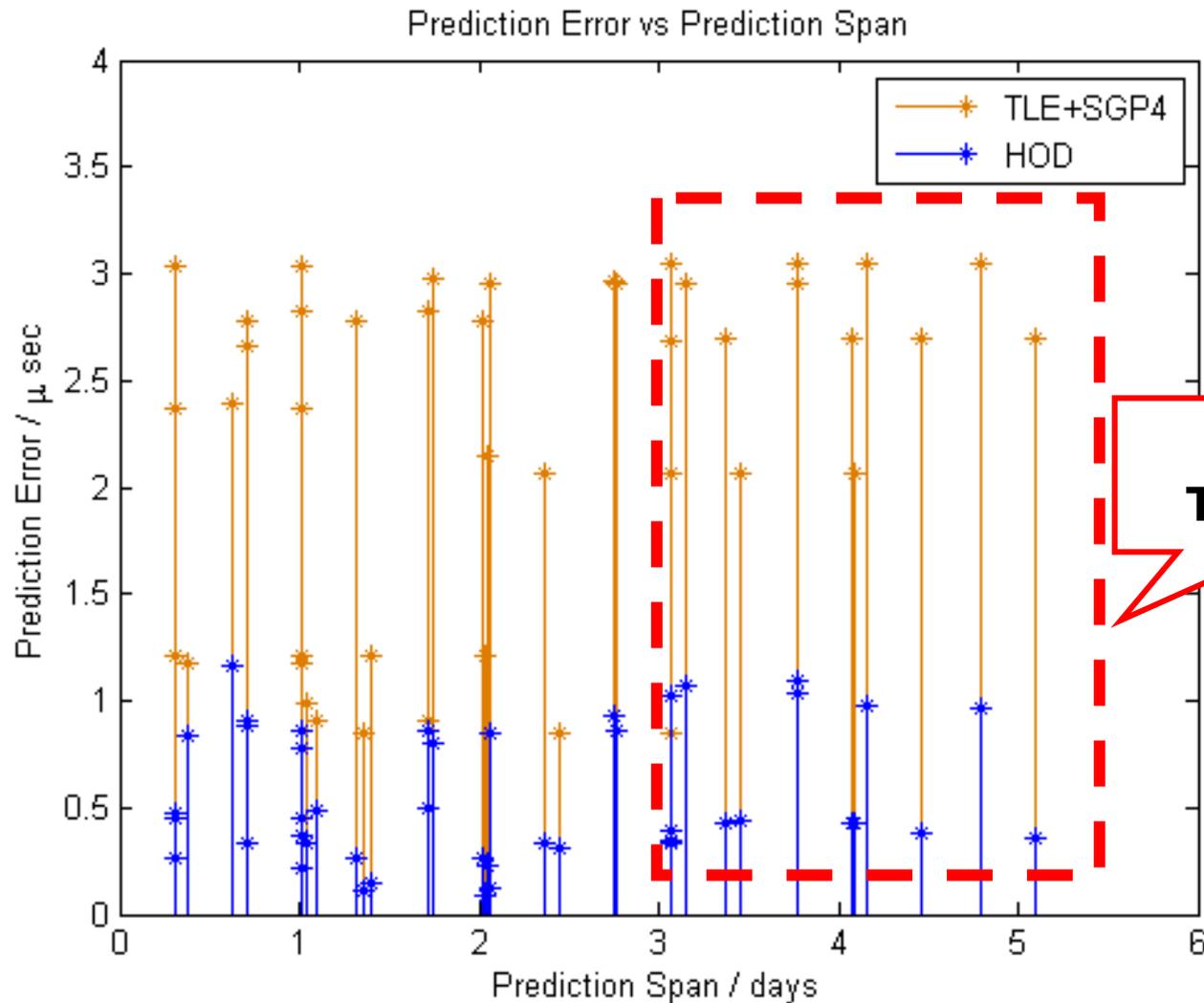
Space Debris Results: Plot



Starlette Inter-station Demo

- Use starlette SLR data from stations A,B
 - Days 0~3: A's starlette data 5 passes
 - Days 4~6: B's starlette data 5 passes
 - Single pass HOD fit
 - Plot results 'Pred error vs Pred span'.
 - Those Pred span >3 (right half) means fitting on A's data while testing with B's data.
 - Result means that fitting on A's data improves prediction on B.
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Starlette Inter-station: Plot



Answers to Questions

- ✓ Yes. It is possible for single station (pass) range data to improve space debris orbit accuracy with respect to TLE.
 - ✓ Other stations tracking on same object would benefit from its orbit improvement.
 - More to do...
 - Topex, Defunct Glonasses, etc.
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References

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 - ❑ G. Kirchner et al. / Advances in Space Research 51 (2013) 21–24
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 - ❑ B. Greene / 13th International Workshop on Laser Ranging Instrumentation Washington DC October 10, 2002
http://cddis.nasa.gov/lw13/docs/presentations/adv_green_1p.pdf
 - ❑ LIANG Zhi-peng, LIU Cheng-zhi, FAN Cun-bo, SUN Ming-guo, TLE-Aided Orbit Determination Using Single-station SLR Data, Chinese Astronomy and Astrophysics 36 (2012) pp. 417-425
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